THE SYSTEMATIC APPROACH TO FLYING FOR AERIAL SURVEY IN SRI LANKA

first experiences with the new Cessna 421

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1. Introduction

In those cases where the so called on-the-job-training methods in flying for aerial survey cannot be applied a systematic approach to the problem is the only solution.

To ensure success-ful operation of the new, well equipped and pressurized Cessna 421 survey aircraft for Sri Lanka this systematic approach is to be followed from the very beginning.

The fact that reliable topographic maps at scale 1 : 50 000 do exist of the whole island and the fact that enough details are recognizable from the air means that no sophisticated and expensive navigation systems like Doppler or INS are needed but that visual navigation is possible.
For that a navigation telescope of the type Wild NF 28 a low priced magnetically slaved gyro compass are the basic instruments, besides this the Cessna is equipped with a standard modern autopilot. The A.P. proved to be very suitable to control the aircraft during survey flight procedures. This fact was of great importance because the aircraft is flown by non-survey-experienced air force pilots.
To be able to apply systematic survey flight procedures some in-flight calibration is necessary. Because of the fact that navigation on maps is possible in Sri Lanka partial calibration is sufficient. For the new Cessna 421 the calibration was combined with the general test and acceptance flight.
In the following the calibration results are presented.

2. Partial in flight calibration for survey navigation on maps

2.1 Calibration of altitude

It had to be demonstrated that the new survey airplane is operating properly up to an altitude of 27 500 ft. For that, test runs have been flown at different altitudes overhead Colombo. This was combined with calibrating the indicated altitude computed for given true altitude.
Temperatures were measured during climb every one thousand feet. The correction formula applied to find the indicated altitude neglects actual humidity data and assumes standard atmospheric temperature lapse rate. The actual altitudes have been derived from scaling the photographs.
As can be seen from the following diagram the altitude errors for the given tropical weather conditions are considerable. For future aerial photographic missions an altitude correction of + 2.3 % is to be applied. This will produce photographs which will meet the scale performance requirements for photogrammetry.

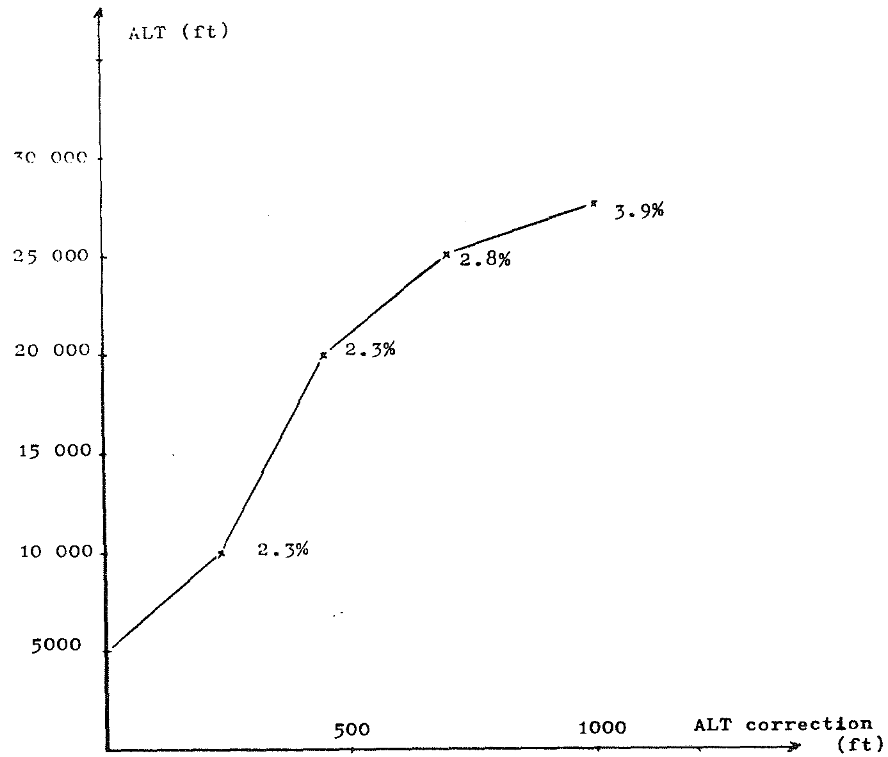


Figure 1

Altitude correction graph

2.2 Alignment of navigation sight and camera

The alignment of both instruments has been checked on ground with respect to the aircraft's longitudinal axis. In flight precisedrift measurements have been carried out by means of both navigation sight and sight of the RC 8 Camera according to the standard procedure (headwind, crosswind, tailwind, crosswind).
It could be veri-fied that the onground-alignment was perfect which means that aircraft's flight axis and longitudinal axis are identical.

2.3 Compass calibration East - West

The compass hat been calibrated in - flight only for headings East and West, because the majority of survey runs in Sri Lanka will be flown in those two directions. Photos have been taken every two minutes. The actual track could be found from plotting the photo positions on the topographic map. Precise drift measurements have been carried out, so that true headings and magnetic headings could be derived. The actual compass headings had been recorded in - flight.

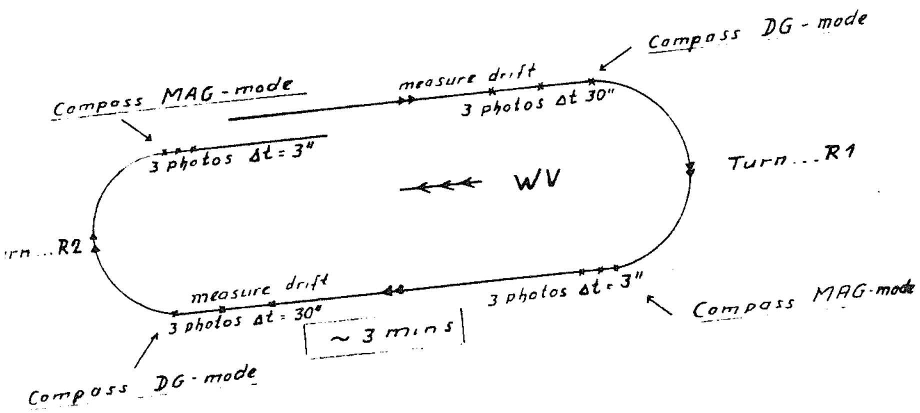
$$DEV_E = MH_E - CH_E = 0.0$$

$$DEV_W = MH_W - CH_W = -0.5$$

2.4 Turn calibration

The performance of the autopilot was found to be such that under normal survey conditions all flights can be carried out on autopilot operation - including the turns.

It was therefore decided to calibrate only the autopilot turns flown on heading bug settings. The following pattern was flown for U-and S-turns.



Turns have been flown in a very systematic way-just as they are to be flown under actual mission conditions.

The following specific actions have been taken for :

a) U-turns : timing, was started 5 degrees before rolling out on the intermediate heading.

b) S-turns : the heading selector was turned in-to opposite direction 5 degrees before the first half of the S-part was completed.

In case of turbulent conditions the resp. S-or U-turns can also be flown manually, applying constant bank angle - the same bank angle which is otherwise introduced by the autopilot. Turn results have shown to be similar for left and right turns so that they could be combined.

Turn calibration results have been worked out in two different ways :

a) <u>assuming A.P. rate 1 turns</u>
This is done to allow the use of turn diagram (e.g. the ITC turn diagram)

b) <u>using the actual A.P. rate of turn</u>
These calibration results can only be used in case a programmable pocket calculator is available /1/. The Cessna 421 A.P. is producing a rate of turn of 2.77 °/sec. at 15000 ft altitude and standard power setting, which is quite close to rate 1 .
In case of bigger differences between rate 1 and actual rate this type of evaluation is to be preferred.

From 12 measurements against 4 mean values a standard deviation of one autopilot turn spacing has been found :

$$m_A = \pm 200 \text{ m}$$

This is indeed for the given altitude (15000 ft) at which the calibration was carried out an excellent result.

3. Survey run interception and turn procedures

To intercept the first survey run of a mission and to come from one run to the next one are the most difficult actions in flying for aerial survey.
Problems can be reduced by applying systematic procedures based on precalculated turns and making use of the calibration data. The following diagram illustrates the principle. Further information can be found from the publication /1/.

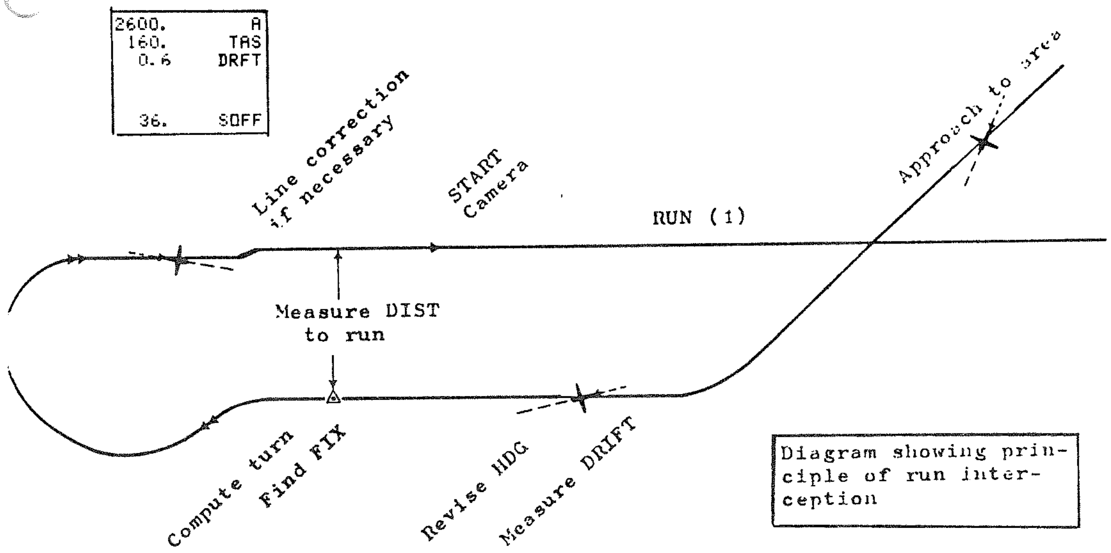
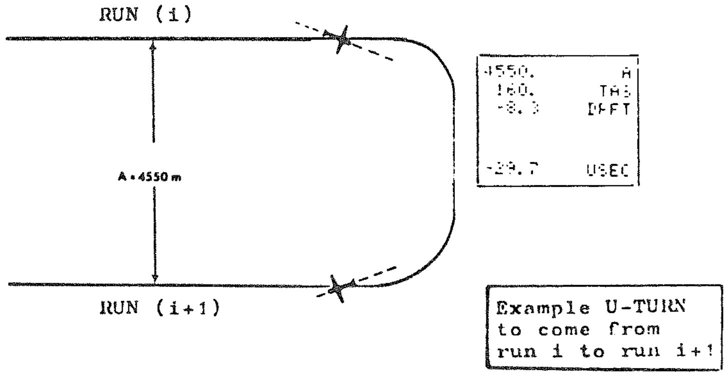


Diagram showing principle of run interception



Example U-TURN to come from run i to run i+1

During a couple of flights even under marginal weather conditions the efficiency of the applied method could be demonstrated and it must be pointed out again that the pilot has been a non-survey-experienced air force pilot. All survey flying was done on autopilot.

Calculation of turns was carried out by means of the programmable pocket calculator TI-59 making use of an improved version of the program published in /1/.

4. Conclusions

The visual survey navigation method can be applied in Sri Lanka.

The acceptance test of the new survey aircraft, a pressurized Cessna 421, was combined with partial in-flight calibration.

The autopilot proved to be suitable to control the aircraft during survey flight procedures.

Actual flights have demonstrated the efficiency of the applied method based on precalculated standard turns, making use of calibration data.

Only a systematic approach to the problem of flying for aerial survey can ensure successful operation from the very beginning. This is important to safe money, time and self-confidence.

Reference

/1/ F.-J. Heimes, Increased survey flight efficiency by means of programmable pocket calculators, ITC Journal 1978 - 4